Comparison of Rabbit, Beef, and Chicken Meats for Functional Properties and Frankfurter Processing

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ABSTRACT

The functional properties of rabbit meat were compared with those of beef and chicken meats. Protein solubilities, water-holding capacities, emulsifying capacities, and binding strengths were approximately equal. Frankfurter emulsions made from rabbit and chicken were formed more easily than those from beef and were more stable. Frankfurters from beef were firmer and were coarser in texture. Sensory evaluations for flavor, texture, and overall acceptability demonstrated that frankfurters made from rabbit meat were equal to those from beef and slightly superior to those from chicken. Quality and sensory scores for rabbit frankfurters containing 15% protein, 20% fat and 1.7% salt were also very acceptable.

INTRODUCTION

RABBIT MEAT could be a significant source of high quality protein in human diets. In addition to a rapid growth rate, high fecundity, and efficient feed conversion, rabbits have a desirable meat-to-bone ratio (Chen et al., 1978; Rao et al., 1978). Rabbit meat has very good nutritional value, being comparatively high in protein, low in fat, low in calories, and low in sodium (USDA, 1963; Sunki et al., 1978).

Rabbit muscle has been studied extensively, often being used for muscle research studies of postmortem biochemistry (Paul, 1964; Buck et al., 1970). The microbiological, biochemical, and organoleptic quality of ground rabbit meat (Sunki et al., 1978) as well as the effects of freezing fresh and cooked rabbit muscle (Ockerman et al., 1980) have also been investigated. Few studies, however, have included the use of rabbit for processed meat products. With the development and acceptance of processed poultry products, this use of rabbit needs to be explored. Baker et al. (1972) compared frankfurters made from chicken, pork, beef, and rabbit using sensory analysis and found rabbit or rabbit-chicken combinations to be better in flavor, juiciness, and tenderness than all-beef frankfurters. Rao et al. (1979) briefly reported that sensory panelists found the juiciness, tenderness, flavor, and general acceptability of rabbit frankfurters to be the same as all beef or commercial frankfurters.

This paper reports comparisons of rabbit, beef, and chicken meats in various functional properties relevant to processed meats. Frankfurters made from these meats were compared by physical tests and sensory panels. The compositions of the rabbit frankfurters were varied to determine the optimal range of protein, fat, and salt in the formulations.

MATERIALS & METHODS

Sources of meat

Boneless beef chuck (from one or two carcasses) was obtained from a local abattoir. Fryer chickens dressed and packed in ice were obtained from a local poultry processor and hand-deboned that same day. New Zealand White rabbits (3.6–4.5 kg) were procured live from a laboratory supplier, exsanguinated, and dressed. Rabbit carcasses were chilled overnight at 1°C and hand-deboned the following day. The meats from six or seven chicken and rabbit carcasses were pooled according to species, trimmed of excess fat and connective tissue, ground, and stored at 1°C until used.

The proximate analyses (Kjeldahl, Soxhlet, and air-drying methods for protein, fat, and moisture, respectively) of the beef, chicken, rabbit, and locally obtained pork backfat were determined by official methods (AOAC, 1975).

Functional tests

The water-holding capacities and protein solubilities were based on methods used by van Eerd (1972) and Buck et al. (1970), respectively. Meat samples were chopped thoroughly in a food processor (Cuisinart Model CFP 9). Five grams of meat and 45 ml of 0.6M NaCl were vigorously stirred by hand in a centrifuge tube, the resultant slurry was chilled overnight at 6°C and then centrifuged at 13,000 x *g* for 15 min followed by centrifugation at 37,000 x *g* for 15 min. The supernatant was decanted after centrifuging at the higher speed, filtered through cheesecloth, and retained. The pellet remaining in each tube was weighed, and the water-holding capacity was calculated as the weight of the sedimented pellet x 100 divided by the original weight of the meat. The soluble protein yield of the retained supernatant was determined on a filtered aliquot by the Biuret method (Gornall et al., 1949).

A press method modified from the procedure used by Wismer-Pedersen (1959) was also used for estimation of the water-holding capacity. One gram of finely ground meat was placed between two tared Whatman #42 filter papers. The filter papers and sample were then placed between two plexiglass plates, and pressure (40 psig) was applied for 1 min by a Carver press. The tissue residue was carefully removed from the filter papers and discarded. The moisture absorbed by the filter papers after removal of the tissue residue is a measure of water-holding capacity.

The emulsifying capacity was determined according to the methods of Swift et al. (1961) and Webb et al. (1970). Fifteen grams of meat were blended with 45 ml 1.0M NaCl for 1 min and then frozen (−30°C) for later assay. After thawing, 3.0g of the slurry were mixed with 50 ml of 1.0M NaCl (chilled on ice); 40 ml of vegetable oil (Wesson oil) at room temperature was added and blended into an emulsion. Additional oil was then added until an abrupt increase in electrical resistance indicated that the emulsifying capacity had been exceeded. The emulsifying capacity was expressed as the volume of oil at the point of emulsion failure per 0.75g meat.

The binding strength test was a scaled-down adaptation of the method of Pepper and Schmidt (1975). In a mixing bowl (Hobart N50), 300g ground meat, 30 ml water, and 7.5g NaCl were mixed at low speed for 15 min. The tacky mixture was stuffed into 29 mm frankfurter casings, cooked to 71°C in an air-conditioned smokehouse, and water-cooled. The weight losses of the meat rolls incurred during cooking were measured. Their binding strength was measured with an Instron Universal Testing Instrument (crosshead speed of 100 mm/min), the round-edged blade being 0.6 cm thick and the distance between the edges of the sample support blocks 2.5 cm.

Frankfurter manufacture

Unless otherwise specified, frankfurters were formulated to contain 11% protein, 25% fat, and 2.6% NaCl based on the weight of lean and fat. An excess 10% water was added to compensate for moisture loss during processing. Each 1200g batch contained 19.3g sucrose, 14.6g commercial frankfurter spice mixture (Baltimore Spice Co.), 0.15g sodium nitrite, and 0.15g sodium ascorbate. The lean meat, salt, spice mix, and one-half of the ice were placed

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in a Hobart silent-cutter (model 84145) that had been modified to have four knives. Nitrite and ascorbate were dissolved separately in small volumes of water and added. After these ingredients were chopped for 2.5 min, the pork fat and remaining ice were added, and chopping continued until the emulsion reached 15.5°C. The emulsion was stuffed into 29 mm cellulose casings, cooked and wood-smoked in an air-conditioned smokehouse to an internal temperature of 71°C, rapidly chilled with a cold water spray, and then stored at 1°C until tested.

Frankfurter testing

The weight loss resulting from the smoking and cooking of the frankfurters was measured. Stability of the uncooked emulsion was determined by the procedure of Meyer et al. (1964). The cook test measured weight changes brought about by immersing the frankfurters in boiling water for 10 min. Warner-Bratzler shear measurements were made with a Chatillon model SD-50 instrument which measured the maximum force needed to penetrate the frankfurter's skin and interior. Penetration force was determined with the Instron by forcing a 0.6 cm diameter plunger through a cross-section of a 2.5 cm (length) frankfurter sample at a rate of 100 mm/min. The maximum force on the plunger when it penetrated into the interior of the sample was reported. The color of freshly cut surfaces from the frankfurter's interior was measured with a Gardner XL-23 Colorimeter (L, a, and b scales).

A sensory panel experienced in making frankfurter evaluations scored the frankfurters for texture, flavor, and overall desirability using a nine-point hedonic scale with nine being defined as "like extremely." Frankfurters were prepared for evaluation by placing them into approximately 500 ml boiling water, returning the water to boiling, removing the water from the heat source, and allowing the frankfurters to stand in the heated water for 10 min. Frankfurters were then sectioned and kept warm in a Vapormatic food warmer (Bastion-Blessing Co.) until presented to the panelists in booths with fluorescent lighting. The panelists were asked whether they found the light color of any of the frankfurters undesirable.

Statistical analyses

In all experiments, replicate values for the individual functional property tests within a sample were averaged for statistical analysis. The number of replicates was two for proximate analyses, smokehouse loss and color scores; three for protein solubility, water-holding capacity, press test, emulsion stability and cook test; four for emulsifying capacity; six for binding strength; nine for Warner-Bratzler shear; and ten for penetration force.

Three lots of meat were sampled in duplicate to compare rabbit, beef, and chicken meat and the data were analyzed using a two-way analysis of variance (Steel and Torrie, 1960). Treatment means were differentiated by Duncan's multiple range test using the mixed effects model and testing treatments against the residual (interaction) mean square. The sensory scores of frankfurters from two lots of meat consisted of the means of 14–16 panelists.

The rabbit frankfurter formulations were analyzed using a one-way analyses of variance. Two lots of meat were sampled in duplicate except for the sensory scores which came from one lot.

RESULTS & DISCUSSION

Rabbit, beef, and chicken

Proximate analyses of these meats varied little (Table 1). Trimming removed most of the intermuscular adipose tissue, particularly from the beef, making the protein contents of the meats higher than that usually reported (USDA, 1963). Two factors led to the incorporation of pork backfat into each formulation: the lack of sufficient rabbit carcass fat for an "all-rabbit" frankfurter (Rao et al., 1978) and the reported overall physical and organoleptic acceptability of rabbit, beef, and chicken frankfurters processed with pork fat (Baker et al., 1972).

Functional property tests revealed few differences between the three species (Table 1). Only the greater water loss exhibited by the chicken meat in the press test was significantly different from that of the beef ($p < 0.05$). The protein solubility, water-holding capacity, emulsifying capacity, and binding tests showed no significant differences between the meats.

The smokehouse weight losses of all the frankfurters were slightly greater than expected (Table 2), resulting in slight increases in actual protein and fat levels of the finished products. The amount of exudate in the emulsion stability test showed that beef produced a significantly ($p < 0.05$) less stable emulsion than did either chicken or rabbit. This lower stability may have resulted from an underchopping of the emulsion by the small capacity silent-cutter. A comparison of the time needed to chop the emulsions to 15.5°C showed that the beef averaged 12.3 min versus 13.8 min for both rabbit and chicken. Both rabbit and chicken emulsions were smooth and fine in texture while that of the beef was noticeably coarser and thicker. The texture and the shorter chopping time of the beef emulsions probably result from the higher connective tissue content of beef.

Table 1—Proximate analyses and functional properties of rabbit, beef, and chicken meat[a]

	Rabbit	Beef	Chicken
Proximate analysis			
Protein (%)	21.1	20.8	20.7
Fat (%)	6.8	4.6	3.7
Moisture (%)	72.8	73.5	74.9
Protein solubility (mg/g)	60.5 A	64.2 A	65.2 A
Water-holding capacity (%)	178 A	134 A	187 A
Press (g water/g)	0.34 AB	0.32 A	0.37 B
Emulsifying capacity (ml oil/0.75g meat)	89.7 A	87.7 A	91.7 A
Binding test			
Cooking loss (%)	13.8 A	15.3 A	15.0 A
Binding strength (kg)	3.67 A	4.04 A	3.92 A

[a] Values in each row with the same letter are not significantly different ($P > 0.05$).

Table 2—Characteristics of frankfurters made with rabbit, beef, and chicken meat[a]

	Rabbit	Beef	Chicken
Smokehouse loss (%)	14.8 A	13.8 A	14.8 A
Emulsion stability test (ml/25g)	0.4 A	3.9 B	0.5 A
Cook test (% change)	1.87 B	−0.01 A	1.80 B
Warner-Bratzler shear (lb)	3.17 A	3.46 A	3.13 A
Penetration force (kg)	0.43 A	0.48 A	0.43 A
Color (Gardner)			
L	70.7 B	50.6 A	71.0 B
a	0.6 A	8.6 B	−0.2 A
b	13.8 B	11.2 A	15.6 C
Sensory score			
Flavor	6.64 AB	6.85 B	6.38 A
Texture	7.18 B	6.08 A	6.92 B
Overall	6.65 B	6.74 B	6.24 A

[a] Values in each row with the same letter are not significantly different ($p > 0.05$).

The cook test indicated the stability of the finished frankfurters under conditions likely to be imposed by the consumer. In this test beef was significantly different from both chicken and rabbit in the percentage of weight change. Beef frankfurters exhibited a minimal (0.01%) weight loss while the chicken and rabbit frankfurters gained 1.80 and 1.87 percent of their respective original weights. A loss of weight indicates the inability of the cooked emulsions to retain fat and water, while a gain indicates the proteins have unused water-holding capacity. The Warner-Bratzler and penetration tests found no significant differences although beef produced the firmest shear and penetration scores.

Color of the frankfurter's interior and exterior (Table 2) differed markedly. Frankfurters processed from rabbit and chicken meats were light colored. The wood smoke browned the surface of the rabbit and chicken frankfurters to give an appealing exterior appearance. The lower Gardner L values for the interior of the frankfurters showed that beef frankfurters were significantly darker than those of chicken and rabbit. Beef frankfurters were much redder (positive Gardner a value) than the others. The higher Gardner b values signified that the rabbit and chicken frankfurters were more yellow than those made from beef.

The sensory panel scored the flavor of the beef frankfurters the highest, with the rabbit frankfurters being scored nonsignificantly and the chicken frankfurters significantly lower. The commercial spice mixture, however, was designed for the standard beef-pork product and it is possible that other spice formulations may improve the flavor scores of rabbit and chicken frankfurters. Rabbit and chicken received the highest texture scores with beef being scored significantly lower. The raw beef emulsion was observed earlier to be coarser in texture which probably influenced the panelists' evaluations of the finished frankfurters. Overall sensory scores of rabbit frankfurters were similar to those of beef and superior to those of chicken. Panelists were asked whether they found the color of any of the frankfurters undesirable; only 23% did. This was an experienced research panel rather than a consumer panel and therefore more accepting of unfamiliar foods.

On the whole, the rabbit meat-pork fat formulation produced a very acceptable frankfurter. These results are in agreement with the sensory evaluations of rabbit frankfurters by Baker et al. (1972) and Rao et al. (1979). The characteristics of the rabbit frankfurters were similar to those of chicken frankfurters, with the most probable defects of the rabbit frankfurters being a soft texture and a light color.

Rabbit frankfurters

With the basic acceptability of the rabbit frankfurters demonstrated, in subsequent experiments the protein, fat, and salt compositions were varied to determine the range over which rabbit would make a satisfactory frankfurter. For dietary purposes, formulations were made with increased protein and decreased fat and salt levels.

Protein levels tested were 11 and 15%, each with two levels of pork fat (Table 3). This set of rabbit frankfurters contained 2.3% NaCl based on the weight of the lean and fat. The greater moisture losses incurred during smoking and cooking were not dependent on the protein concentration but were greater with the high moisture-low fat containing emulsions. The emulsion stability test showed no significant differences ($p > 0.05$) between the four compositions in the amount of exudate, all values were less than 1.0 indicating a good emulsion (Ackerman et al., 1979). During the cook test all samples gained weight, also demonstrating that good emulsions were achieved.

The Warner-Bratzler shear forces were significantly greater with the higher protein frankfurters. Within a protein level, shear forces tended to be greater with frankfurters containing the higher fat level. The penetration forces changed in a similar manner, indicating that the firmness was not just a consequence of the skin. Baker et al. (1969) showed that increases in the fat levels of chicken frankfurters resulted in an increase in the shear values and that shear values were directly related to protein levels.

Flavor scores were all acceptable, although the 15% protein-10% fat frankfurters were judged to be significantly less favorable than the others. No significant differences were detected in the texture, but the higher protein frankfurters did receive lower scores. This may have resulted from a slightly tougher skin characteristic of the higher protein frankfurters. Overall sensory scores also were not significantly different, but they did reflect the flavor and texture scores.

Because the 15% protein-20% fat frankfurters were judged to be nearly equal to the best composition and would have dietary advantages, this particular formulation was tested with three salt concentrations (Table 4). Smoke-

Table 3—Characteristics of rabbit frankfurters made with different protein and fat levels[a]

	Formulations			
% Protein	11	11	15	15
% Fat	20	30	10	20
% Water	64	54	70	60
Smokehouse loss (%)	16.9 C	14.8 AB	16.5 BC	14.1 A
Emulsion stability test (mg/25g)	0.8 A	0.2 A	0.2 A	0.0 A
Cook test (% change)	1.20 B	0.80 AB	0.24 A	1.02 B
Warner-Bratzler shear (lb)	2.64 A	3.14 A	4.29 B	5.16 C
Penetration force (kg)	0.48 A	0.47 A	0.62 B	0.79 C
Sensory score				
Flavor	6.86 A	7.00 A	6.20 B	6.93 A
Texture	6.86 A	6.93 A	6.60 A	6.26 A
Overall	6.66 A	6.93 A	6.33 A	6.53 A

[a] Values in each row with the same letter are not significantly different ($p > 0.05$).

Table 4—Characteristics of rabbit frankfurters made with different salt levels[a]

	% Salt		
	2.3	1.7	1.2
Smokehouse loss (%)	13.9 A	14.5 B	13.7 A
Emulsion stability test (ml/25g)	0.0 A	0.1 A	0.6 B
Cook test (% change)	0.79 B	0.35 B	−0.20 A
Warner-Bratzler shear (lb)	4.82 B	4.36 B	3.15 A
Penetration force (kg)	0.82 B	0.75 B	0.63 A
Sensory score			
Flavor	6.87 A	6.93 A	6.37 A
Texture	6.18 A	6.56 A	5.68 A
Overall	6.56 A	6.50 A	5.68 B

[a] Values in each row with the same letter are not significantly different ($P > 0.05$).

house losses of these frankfurters were similar. The results of the other four physical tests showed changes with decreasing salt levels, significantly ($p < 0.05$) so with 1.2% salt. The emulsion stability test showed no exudation from emulsions with 2.3 and 1.7% salt. The losses with 1.2% salt, although significantly different from the other two, were still not considered excessive. When subjected to a cook test, the frankfurters containing the higher two salt concentrations gained weight, while the 1.2% level lost a small amount of weight. The Warner-Bratzler and penetration force values showed slight decreases in firmness of frankfurters with 2.3 to 1.7% salt and significant declines with 1.2% salt.

These trends in the physical tests were not as pronounced in the sensory panel scores. Flavor and texture scores were not significantly different even though they were lower for the 1.2% salt frankfurters. Overall scores were, however, significantly lower at the 1.2% salt level. The 1.7% salt frankfurters had slightly higher flavor and texture scores than the standard 2.3% salt frankfurters, but overall sensory ratings between these two formulations were equal.

These data indicate that a higher protein, lower fat, and lower salt formulation would be organoleptically acceptable and provide a product having more favorable dietary properties. Reduction of the formulation's salt level would require further consideration with regard to microbial quality before such a change could be implemented.

REFERENCES

Ackerman, S.A., Miller, A.J. and Swift, C.E. 1979. A phase testing method for rapidly determining the stability of sausage emulsions. J. Food Sci. 44: 174.

AOAC. 1975. "Official Methods of Analysis," 12th ed. Association of Official Analytical Chemists, Washington, DC.

Baker, R.C., Darfler, J., and Vadehra, D.V. 1969. Type and level of fat and amount of protein and their effect on the quality of chicken frankfurters. Food Technol. 23: 808.

Baker, R.C., Darfler, J.M., and Vadehra, D.V. 1972. Acceptability of frankfurters made from chicken, rabbit, beef and pork. Poultry Sci. 51: 1210.

Buck, E.M., Stanley, D.W., and Commissiong, E.A. 1970. Physical and chemical characteristics of free and stretched rabbit muscle. J. Food Sci. 35: 100.

Chen, C.P., Rao, D.R., Sunki, G.R., and Johnson, W.M. 1978. Effect of weaning and slaughter ages upon rabbit meat production. 1. Body weight, feed efficiency and mortality. J. Anim. Sci. 46: 573.

Gornall, A.G., Bardawill, C.J., and David, M.M. 1949. Determination of serum proteins by means of the Biuret reaction. J. Biol. Chem. 177: 751.

Meyer, J.A., Brown, W.L., Giltner, N.E., and Guinn, J.R. 1964. Effect of emulsifiers on the stability of sausage emulsions. Food Technol. 18: 1796.

Ockerman, H.W., Organisciak, C.S., and Van Stavern, B.D. 1980. Effect of sauces, cooking pre- and post-freezing, and frozen storage on rabbit muscle tissue. J. Food Sci. 45: 1070.

Paul, P.C. 1964. The rabbit as a source of experimental material for meat studies. J. Food Sci. 29: 865.

Pepper, F.H. and Schmidt, G.R. 1975. Effect of blending time, salt, phosphate, and hot-boned beef on binding strength and cook yield of beef rolls. J. Food Sci. 40: 227.

Rao, D.R., Chawan, C.B., Chen, C.P., and Sunki, G.R. 1979. Nutritive value of rabbit meat. In Cheeke, P.R. ed., The domestic rabbit: Potentials, problems, and current research. Proc. Symp. 71st Ann. Meet. Amer. Soc. Anim. Sci., p. 53—59. OSU Rabbit Research Center, Oregon State Univ., Corvallis, OR.

Rao, D.R., Chen, C.P., Sunki, G.R., and Johnson, W.M. 1978. Effect of weaning and slaughter ages on rabbit meat production. 2. Carcass quality and composition. J. Anim. Sci. 46: 578.

Steel, R.G.D. and Torrie, J.H. 1960. "Principles and Procedures of Statistics." McGraw-Hill Book Co., New York.

Sunki, G.R., Annapureddy, R., and Rao, D.R. 1978. Microbial, biochemical and organoleptic changes in ground rabbit meat stored at 5 to 7 C. J. Anim. Sci. 46: 584.

Swift, C.E., Lockett, C., and Fryar, A.J. 1961. Comminuted meat emulsions—The capacity of meats for emulsifying fat. Food Technol. 15: 468.

USDA. 1963. Composition of Foods. Agriculture Handbook No. 8. U.S. Gov't Printing Office, Washington, DC.

Van Eerd, J.P. 1972. Emulsion stability and protein extractability of bovine muscle as a function of time postmortem. J. Food Sci. 37: 473.

Webb, N.B., Ivey, F.J., Craig, H.B., Jones, V.A., and Monroe, R.J. 1970. The measurement of emulsifying capacity by electrical resistance. J. Food Sci. 35: 501.

Wismer-Pedersen, J. 1959. Quality of pork in relation to rate of pH change post mortem. J. Food Res. 24: 711.

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Reference to a brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.